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Questions of the Day and of the Fray

No. II

Mental Defect, Mal-Nutrition, and the Teacher's Appreciation of Intelligence

A REPLY TO CRITICISMS OF THE MEMOIR ON 'THE INFLUENCE OF DEFECTIVE PHYSIQUE AND UNFAVOURABLE HOME ENVIRONMENT ON THE INTELLIGENCE OF SCHOOL CHILDREN'

BY

DAVID HERON, D.Sc.

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MENTAL DEFECT, MAL-NUTRITION AND THE TEACHER'S APPRECIATION OF INTELLIGENCE

A REPLY TO CRITICISMS OF THE MEMOIR ON 'THE INFLUENCE OF DEFECTIVE PHYSIQUE AND UNFAVOURABLE HOME ENVIRONMENT ON THE INTELLIGENCE OF SCHOOL CHILDREN'.

In the above Galton Eugenics Memoir, the conclusion was reached that home environment, as measured by clothing, cleanliness, nutrition, stature, and weight, could not be the chief determining cause of the differentiation of intelligence; nor was defective physique its source. Some contribution unfavourable home environment and defective physique may make to the degree of intelligence, but even if this be finally demonstrated, it will be found to be a 'second order' contribution, possibly even an indirect effect of race and stock, the abler children being those of fitter parents who provide better homes and hand down better physique. Other factors of environment have yet to be discussed, but so far—and this generalization covers much more than the 400 coefficients calculated in the memoir disclose—there is no sign of an environmental condition producing an effect on the mentality of the child at all comparable with the known influence of heredity.[1] It should be noted also that the purpose of the memoir was twofold: (*a*) to illustrate the difficulties that arise in attempting to make reliable and comparable observations on school children; and (*b*) to indicate the difficulties met with in

[1] See *Memoir*, p. 60.

the statistical treatment of such observations if they are not made with due regard to the needs of the statistician.[1]

The observations on which this investigation was based were made on the children of fourteen schools in London, and the recording work was carried out under the auspices of the Chief Medical Officer to the Education Committee of the London County Council. Particulars were given for 4,286 boys and 4,474 girls, regarding mental capacity, age, standard, height, weight, and condition of the teeth, and in certain schools only regarding state of nutrition, condition of the clothing, state of cleanliness, power of hearing and condition of the cervical glands, tonsils, and adenoids.

With the exception of the estimate of the mental capacity of the children, the whole examination was carried out by the school medical officers, and although different methods were used in different schools, the method of examination was uniform throughout each school, the observations throughout each school were made by one medical officer, and in the memoir itself each school was dealt with separately. The estimates of the mental capacity of the children were of course made by the individual teachers.

The results of this investigation have been somewhat severely criticized by Mr. G. Udny Yule in the *Journal of the Royal Statistical Society*[2] and again in *School Hygiene*.[3] No objection has, however, been raised to the classifications made by the school medical officers, and these will not be dealt with here.

[1] *Memoir*, p. 1.

[2] Vol. lxxiii, part v, p. 547.

[3] Vol. i, p. 473. To those aware of the high correlation between a teacher's estimate of general intelligence, and the class and examination places of children, Mr. Yule's criticism that 'the data were of no value for any serious purpose' falls singularly wide of the mark. We ask in this, as we have had recently to do in many other cases, why do not these critics set to work and find out facts before they criticize?

The whole of Mr. Yule's criticism turns on the weight to be given to the teachers' estimates of the intelligence of the school children. The scale of intelligence used divided the children into five categories: 'brilliant', 'above the average', 'average', 'under the average', and 'very dull and backward'. Now this is of course a purely verbal classification, and is condemned by Mr. Yule as being vague, and the estimate of mental capacity is said to be relatively as well as absolutely useless. We shall consider later to what extent Mr. Yule himself is consistent in his condemnation of such verbal classifications.

Now it is quite true, as Mr. Yule says, that the percentage of children who are classed as brilliant varies from 3 % to 33 % in the case of the boys and from 1 % to 33 % in the case of the girls, and at first sight this may seem to discredit the returns. But Mr. Yule has apparently not noticed that these high percentages occur in the boys' and girls' departments of the same school (No. 1), and I have satisfied myself, by going carefully over the records in the different standards, that the boys and girls were not classified by the same teachers. This shows that although the term 'brilliant' covers a wider range of mental capacity in this school than in any other, yet the use of the term has been on the whole consistent throughout the school in question.

The classification of intelligence is admittedly difficult, and in the case of the data under discussion not so satisfactory as might be wished, but this was clearly pointed out in the memoir itself. Every point that could in any way tell against the classification made by teacher or school medical officer was included and examples of faulty classification were even given from material that was not used at all, and in fact no inconsiderable part of Mr. Yule's reviews consists of extracts from the memoir itself. With all these points

in view I held and still hold that the estimates of intelligence made by the teachers were of value and could be used for the study of the influence of environment on intelligence.

It was pointed out in the memoir that the position of the child in the standard, corrected for age, might well be used as a measure of general intelligence. This meets with Mr. Yule's approval, and he says that 'it is not clear why it was not adopted in the present memoir'. But had it been given it certainly would have been used, if not directly, certainly as a check on the estimates made by the teachers, since the amount of correlation between place in standard and the teacher's estimate of intelligence furnishes a perfectly reliable test of the value of the latter, and it is for this purpose that a knowledge of place in class is of most value.

Now we cannot apply this test in the case of the L.C.C. data, but we can appeal to other data, collected under much the same conditions. Under the auspices of the Royal Commission on Physical Training in Scotland (1902), Professor Matthew Hay carried out an examination of a number of Aberdeen school children. Professor Hay kindly placed these returns at the disposal of the Galton Laboratory, and they are discussed by Professor Pearson and Miss Jones in a recent number of *Biometrika*.[1] The material consisted of an examination of 249 boys taken from four Aberdeen schools. For each boy there was given an estimate of mental capacity by the class teacher who had not volunteered for the work, nor was he specially selected.

The scale of intelligence used was again somewhat vague. The children were divided into four classes: excellent, good, moderate, and dull. It should be noted that the

[1] *Biometrika*, vol. vii, part 4, p. 542.

boys were judged not only by different teachers, but also in different schools. Now there was in this case available at the same time the place of each boy in his class, so that on this material we can test directly the value of such estimates of general intelligence by teachers in elementary schools.

For a full discussion of this material, the reader must be referred to the original paper, but the results may be summarized here. The relationships between mental capacity, place in class, age, and standard were determined as follows:

Intelligence and Age	$r_{13} = -\cdot1830$
Intelligence and Place in Class . .	$r_{12} = \cdot7246$
Intelligence and Standard . . .	$r_{14} = -\cdot0558\ (-\cdot2123)$
Place in Class and Age	$r_{23} = -\cdot0484$
Place in Class and Standard . . .	$r_{24} = \cdot0580\ (\cdot1553)$
Age and Standard	$r_{34} = \cdot9366$

The alternative values are accounted for by the use of different processes.

The correlation between 'General Intelligence' as estimated by the teacher and Position in Class for constant Age and Standard was then found to be:

With lower values of r_{14} and r_{24} . .	$\rho_{12} = \cdot70 \pm \cdot02$
With higher values of r_{14} and r_{24} . .	$\rho_{12} = \cdot99 \pm \cdot01$.

Professor Pearson, in discussing these results, says:

'We may safely draw from these results the conclusion that the teacher's estimate of general intelligence is not a purely idle character, wholly valueless owing to the personal equation of the teacher. Whatever else it may be, it is highly correlated with the place which the student will take in an examination test, and accordingly has at least one quite definite significance. . . . Those who complain of the different percentages of the divers grades of intelligence of the children in the different standards of the same elemen-

tary school often seem unaware that the same sample does not pass through all the standards, at one stage there is a rejection of the very dull and at another the retention of the dull class. The main facts brought out are the substantial correlation between the teacher's estimate of general capacity and examination test, and the fact that extreme allowance for age and standard tends to emphasize this relationship rather than to show that the teacher's estimate is of little value.' Absolutely confirmatory results have recently been reached by Messrs. Gilby and Waite for much larger numbers.

A considerable part of Mr. Yule's criticism is devoted to a comparison of the results of the L.C.C. investigation with those found in a previous investigation carried out by Dr. Francis Warner[1] between 1888 and 1894 in which 100,000 children were examined. There has thus been forced upon the present writer the unpleasant duty of criticizing in detail an investigation carried out nearly twenty years ago, a duty which he would have been glad to have been spared. Mr. Yule has himself already published a very extensive analysis of Dr. Warner's material in his paper 'On the Association of Attributes in Statistics'[2]; it is very unfortunate that Mr. Yule not only made no attempt to estimate the value of the material on which he expended so much energy, but that he laboured under the additional disadvantage of using a 'coefficient of association' which he now admits cannot be compared with the correlation coefficient.[3] How widely these coefficients of

[1] *Report on the Scientific Study on the Mental and Physical Conditions of Childhood.* Published by the Committee, Parkes Museum. London, 1895. *Journal of the Royal Statistical Society*, vol. lvi, p. 71, and vol. lix, p. 125. *British Medical Journal*, July 27, 1889, p. 187. *Report of the British Association for the Advancement of Science*, 1893, p. 614, &c.

[2] *Phil. Trans. Royal Society*, A. 238, 1900, pp. 257–319.

[3] In Mr. Yule's paper, the association coefficient was used as if it were

association differ from the correlation coefficients calculated on the same material may be seen from the following table, which gives the coefficients of association [1] for various parts of Dr. Warner's data, and the coefficients of correlation [2] for the same data which had to be calculated by Mr. Yule for his criticism of the L.C.C. investigation.

I. TABLE SHOWING THE RELATIONSHIP BETWEEN MENTAL DULLNESS AND BAD NUTRITION DEDUCED FROM (*a*) ASSOCIATION COEFFICIENTS AND (*b*) CORRELATION COEFFICIENTS.

Material.	Coefficient of Association.	Coefficient of Correlation.
26857 Boys 1888–1891	·79	·53
26287 Boys 1892–1894	·82	·56
23143 Girls 1888–1891	·86	·64
23713 Girls 1892–1894	·84	·58
2631 Jewish Boys 1892–1894	·71	·43
2668 Jewish Girls 1892–1894	·77	·47

This shows that the coefficient of association is about 50 % higher than the coefficient of correlation so far as this material is concerned, but the value of the association coefficient depends on the choice of axes; Mr. Yule in the *Phil. Trans.* paper already cited [3] gives a table for the special case where the axes are taken at the mean values of the variables showing a maximum difference of ·1 throughout the whole range of the correlation coefficient. When the

directly comparable with the correlation coefficient. He says (p. 300): 'The associations, however, are all high (very high compared with most coefficients of organic correlation with which we have to deal), ranging from ·794 to ·952.' No comparison, except possibly as to sign, can be made between the two types of coefficients.

[1] Extracted from Mr. Yule's *Phil. Trans.* paper, pp. 300, &c.

[2] Extracted from Mr. Yule's review in the *Journal of the Royal Statistical Society*, vol. lxiii, p. 549.

[3] *Phil. Trans. Royal Society*, 1900, p. 276.

axes are markedly divergent from the means, as in the present data, practically no reliance whatever can be placed on the coefficient of association. It is, however, rather to the value of the data used by Mr. Yule than to the methods employed by him, that attention must be directed.

Dr. Warner's investigation was based on 100,000 children in all, and of these the first 50,000 were examined by Dr. Warner himself within a period of three years. Giving forty weeks to the year, five days a week, five hours a day, which is all that is possible (but scarcely probable) in school medical inspection, we find that Dr. Warner can only have devoted on the average $3\frac{1}{2}$ minutes to each child. *Yet the schedule which Dr. Warner used contained over one hundred groups of categories and several hundred categories altogether.*[1]

[1] Dr. Warner's work, if very superficial and of little value in itself, was of great service in directing attention to the question of nervous symptoms in children. Out of his work and the Report of the Commission on the Blind and Deaf of some dozen years earlier came the movement for special schools. But this very fact of the creation of special schools has apparently been overlooked by Mr. Yule, for their existence has removed the extreme mental defectives from the L.C.C. survey, which I was considering. Dr. Warner *started* with the view that such mental defect was due to ill-nutrition, and his estimate of mental defect was largely based on appearances also due to ill-nutrition, and not unnaturally he found a high correlation. The ages of the 82 % of so-called 'normal' children were not taken, and only the ages of the abnormal children in the 1892–4 investigation were published. Thus the ages of 8,941 children out of 50,000 are tabulated, but on this partial knowledge no allowance can be made for growth changes, and except for his crude numbers there is nothing which can be determined about his so-called 'normal class'. Dr. Warner's belief that mental defect can be removed by feeding and training is not in accordance with the best current medical experience. If it were true the special schools would be producing normal individuals, whereas the real problem of feeble-mindedness turns on what to do with the defective children when they leave the special schools. Again, if mere nutrition could develop mentality, the heavy, overfed children who come into the schools from the Poor Law system would not present such hopeless material for the teachers' efforts as they do. There is, in fact, no real evidence that mental defect, pure and simple, arises from ill-nutrition; there is a condition of amentia—lowered

Here are a few examples of groups of categories extracted from Dr. Warner's report:

11. External Ear defective in its parts, size, or form. Abnormality in size, proportioning, absence of parts, texture of skin are here recorded. The ear may be outstanding with great convexity posteriorly and concavity in front; the helix or portions thereof and the antehelix may be absent; the skin over the cartilage may be tight and adherent, coarse in texture with varicosities. The ears may be asymmetrical, and the lobes may be adherent to the face. (*Report*, p. 73.)

The ear may be red or bluish. The helix may be absent or contracted, forming a cavelike ear, or may be absent partially as in the middle part of the margin or for the whole rim. As to the adherent lobe of the ear, it was often seen but not specially in ears otherwise defective, and no reason

mental activity—associated with some small and ill-nourished children, but in these cases there are, as a rule, other features which seem to indicate that both mental defect and ill-nutrition have a common origin, and are not necessarily cause and effect. This note may suggest two points: (1) that if Dr. Warner's data were really reliable, they would not lead to correlations comparable with those based on schools from which the mentally defective have been removed. It would be as profitable to compare correlations between intelligence in the general population and other characters, say ill-nutrition itself, before and after the insane had been removed from it. And (2) that Mr. Yule does not appear to have taken any advice, since he wrote his original memoir, as to the current medical opinion as to mental defect, nor do his criticisms allow us to suppose that he in the least appreciates the evidence for the hereditary character of this defect. Those who have had experience of insanity know how in a normally developed individual the appearance of insane tendencies may be heralded and accompanied by ill-nutrition. There is no reason to doubt that a similar association, which must not be interpreted as a causation, may occur in the case of mental defect. Further, it is almost impossible to examine a large number of mentally defective or imbecile children without at the same time recognizing the prevalence among them of associated physical defects of all kinds, and these occur not only in the defectives themselves, but in their relatives. This general degeneracy, expressible in terms of the failure of a control determinant, suffices to explain much that Dr. Warner observed, without compelling us to the conclusion that mental defect flows from ill-nutrition.

appeared for considering it a marked sign of defect. Supernumerary ears were represented by outgrowths in front of the tragus, and depressions apparently representing remnants of branchial clefts were occasionally seen at the upper termination of the helix. There were two or three children with almost total absence of the concha, which was represented by a cartilaginous growth only. In one girl the ear was displaced several inches by the contraction of a cicatrice. (*Report*, p. 22.)

27. Features coarse, heavy, flat, or lips thick. The features may be large or ill-proportioned. The separate features may not be individually malformed but disproportionate one to another or to the size of the face; thus the nose may be small, the face large, round, flat, the features rising from the plane of the face. The lips may be thick and protuberant. (*Report*, p. 75.)

39. Palpebral Fissures defective in size or form. The eyelids may be small as well as the palpebral fissures or openings between them both, in their vertical and transverse measurements. In some cases the opening is not symmetrical, being wider on the inner than on its outer half. The transverse axis may slope outwards and upwards or outwards and downwards, instead of being horizontal. (*Report*, p. 76.)

These examples will suffice to give some idea of the manner in which 'Developmental Defects' were classified. Space does not permit a full description of the 'Nerve Signs' noted by Dr. Warner, but their short titles will probably be found sufficient. They are:—(43) General Balance defective. (44) Expression defective.[1] (45) Frontals

[1] This deserves to be given in full: (44) Expression defective.—Want of changefulness, vacancy, fixed expression. The visible muscular action and balance seen in a face may be described, and still there may be an expression

overacting. (46) Corrugation. (47) Orbicularis Oculi relaxed. (48) Eye Movements defective. (49) Head Balance asymmetrical or drooped. (50) Hand Balance weak. (51) Hand Balance nervous. (52) Finger twitches. (53) Lordosis. (54) Other Abnormal Nerve Signs (55 to 63). (55) Deaf or Hearing defective. (56) Grinning or Over-smiling. (57) Mouth open or Jaw drooped. (58) Over-mobile. (59) Response in Action defective. (60) Speech defective. (61) Statuesque or Immobile. (62) Tremor. (63) Miscellaneous Abnormal Nerve Signs.

Now there are over one hundred of such groups of categories, and yet no more than $3\frac{1}{2}$ minutes can, on the average, have been given to each child.

It is impossible to reproduce the whole of Dr. Warner's categories here; they have only to be examined to satisfy any one that no examination worthy of the name could have been carried out in the time at Dr. Warner's disposal. Even if we assume that *no time at all* was spent on the 82 % of the children who are said to be 'normal', as regards every one of these hundred groups of categories, we find that only 20 minutes at a maximum could have been given to each of the remaining 18 %!

Lest the reader should imagine that some of these categories may turn out to have little relationship to the intelligence of the children, it should be noted that of 50,000 children seen in 1888–91, 7·3 % are said to be 'mentally dull'.[1] Of 1,315 children with defective ears, however, 32·0 % of the boys and 38·4 % of the girls are said to be 'mentally dull', while of 251 children whose features were 'coarse', 49·6 % of the boys and 41·3 % of the girls are registered as 'mentally dull'.

that cannot be described anatomically. A face may be balanced or moved abnormally by action of its muscles.

[1] The value of this classification of intelligence is discussed below.

It is almost entirely on this material that Mr. Yule has based his elaborate memoir on the Association of Attributes in Statistics.

Now Mr. Yule has condemned the L.C.C. investigation on the ground that it is 'an excellent example of the danger of purely verbal classification', while he accepts Dr. Warner's investigation as one in which 'continuity of standard was ensured'.

But among the multitude of categories dealt with by Dr. Warner there are some which are capable of quantitative measurement, and particular attention must be drawn to his treatment of these characters. In discussing size and shape of head, for instance, Dr. Warner remarks:—'Of all defects in development, abnormalities of the cranium appear to be the most important, being the most numerous and having the highest pathological co-relations. The size and probable volume of the brain is a point of first class importance, and the size of the cranium is in children a fair indication of the size of the brain.' (*Report*, p. 20.)

Let us therefore examine in detail Dr. Warner's treatment of cranial abnormalities, and let us confine our attention to large and small crania which could have been directly measured. On p. 72 of his *Report* we find the following description of these categories:

'A. 1. Cranium defective includes any defect in size, form, proportions, or ossification of the cranium. A given case may come under more than one of the classes below. As to a standard of normal size: In a well-developed child of good potentiality, the head circumference at 9th month is 17½ inches, at 12 months 19 inches, at 7 years 20 to 21 inches. This is rather a high standard of size.

'A. 2. Cranium large. A head of 22 inches circumference or over may be considered large in a schoolchild;

allowance must be made for age. Doubtless many of those cases are rachitic. Hydrocephalus is entered in its own class.

'A. 3. Cranium small. The point of size of head is recorded as apart from the size of the child for its age. The volume is estimated in relation to the normal for age. This is determined by inspection, by the open hand placed upon the head, and by the measuring tape. A head with circumference over 20 inches at any school age is not registered as small; usually the small heads are 18 to 19½ inches circumference. Small head is noted independent of stature.'

On p. 20 of his *Report* he says further:

'In estimating the volume of a cranium it is preferable to proceed by inspection; noting its form and not solely the circumference or other measurements; good estimate of both form and volume may be obtained by placing the open hand on the child's head, subsequently using a tape measure.'

Dr. Warner's account of his procedure is again varied in his Report to the British Association[1] in 1893. He says there: 'Thus the cranium was not noted as small unless the circumference be less than 19 inches at eight years old or 19½ among older children, while the general volume is estimated by the open hand placed upon it.'

Thus we find that 'small heads are usually 18 to 19½ inches'; 'the cranium was not noted as small unless the circumference be less than 19 inches at eight years old or 19½ among older children'; 'the normal at seven is 20 to 21 inches'; and 'a head of 22 inches is to be considered large'.

Anything more indefinite and vague than this it is difficult to imagine, and it is quite clear that notwithstanding Dr. Warner's own statement as to the use of the measuring tape, the heads of the children were not measured by him.

[1] *Report of the British Association*, &c., 1893, p. 615.

It may be gravely doubted whether he even placed his hand, indeed, on the heads of the 82,000 children passed as 'normal'. No growth curves were found, no allowance made for differences between the sexes, and no definite standard for large or small heads ever formulated. Yet in Mr. Yule's analysis of Dr. Warner's data he has not a word of criticism for methods such as this.

But we can go further. In Table XVI of his *Report* (p. 103) Dr. Warner finds that of the children with small crania, 41·4 % of the boys and 45·5 % of the girls are 'mentally dull' as compared with 8·3 % and 6·3 % in the whole series[1] investigated. There is thus apparently a very close relationship between mental defect and cranial defect. Now this problem has been directly investigated by Professor Karl Pearson.[2] The material dealt with consisted of (*a*) the head measurements of 1,000 Cambridge graduates, together with the examinational standing of each; and (*b*) the head measurements of over 5,000 school children, together with an estimate by the teachers of the intelligence of the children. Both sets of material gave the same results, but only the observations on school children will be summarized here. The children were placed in six groups for intelligence ranging from 'Quick Intelligent' to 'Very Dull'. The 'Very Dull' formed about 2 % of the whole as compared with 7 % of Dr. Warner's school children, who were classed as 'Mentally Dull'. Thus the 'Very Dull' were of somewhat lower intelligence than Dr. Warner's 'Mentally Dull' group. In the following Table I have extracted from Professor Pearson's results the means and standard deviations for the head length, head breadth, head height, and

[1] 1888 investigation only.

[2] *R. S. Proc.*, vol. lxix, pp. 333–42. *R. S. Proc.*, vol. lxxi, pp. 106–14. *Biometrika*, vol. v, pp. 105–46.

cephalic index for boys and girls among all children and among the 'very dull' children, and have also given the

II. TABLE SHOWING THE MEANS AND VARIABILITIES OF HEAD MEASUREMENTS OF ALL CHILDREN AND OF VERY DULL CHILDREN.

Measurements.	Constants.	Boys.			Girls.		
		All.	Very Dull.	Differences.	All.	Very Dull.	Differences.
Head Length	Means	184·44	180·19	4·25 ± ·73	180·14	178·57	1·57 ± ·74
	S. D.'s	6·51	7·05	·54 ± ·52	6·26	6·97	·71 ± ·52
	No. of Observations	2298	43·5		2188	41	
Head Breadth	Means	145·23	143·36	1·87 ± ·62	140·58	136·55	4·03 ± ·95
	S. D.'s	5·70	6·02	·32 ± ·44	6·51	9·17	2·66 ± ·67
	No. of Observations	2299	43		$210\frac{5}{2}$	43	
Head Height	Means	127·43	124·84	2·59 ± ·73	124·40	123·69	·71 ± ·81
	S. D.'s	6·63	6·92	·29 ± ·52	6·70	7·23	·53 ± ·57
	No. of Observations	2290	41·5		2166	37	
Cephalic Index	Means	78·88	79·48	− ·60 ± ·33	78·43	76·96	+ 1·47 ± ·49
	S. D.'s	3·22	3·15	− ·07 ± ·23	3·89	4·60	·71 ± ·34
	No. of Observations	2345	43		2226	41	

probable errors of the differences. It will be seen that the differences between the means are all small, although in

some cases they are significant with regard to their probable errors. Professor Pearson concluded that there is a slight correlation between intelligence and size of head, but that this correlation is so small that it would be absurd to endeavour to predict the intellectual ability of an individual from his or her accurate head measurements. It is clearly impossible to detect such slight differences by the rough and ready methods adopted by Dr. Warner.

Now although the mean values differ to such a small extent, it is possible that mental dullness might be associated both with very large and with very small heads. We must then compare the variability of the 'very dull' with that of all the children. These results are also given in Table II, and it will be seen that only in two cases out of eight is the difference more than twice its probable error, and even in these cases we find a possibly significant difference among the girls associated with a non-significant difference among the boys. Dr. Warner's conclusion that mental dullness is closely associated with size of head may be rejected, therefore, as arising solely from the methods employed.

His treatment of shape of head deserves further mention. Among cranial 'defects', Dr. Warner includes cases where crania are 'dolichocephalic'. Now 'dolichocephalic' is a perfectly definite term. It is applied to heads whose cephalic index is less than 75. Dr. Warner, however, applies it to 'Heads long in antero-posterior diameter', i.e. he applies the term not to an *index*, but to a *length*, and further does not say within what limits crania are to be regarded as dolichocephalic. It is interesting to note that he applies this term to only 81 children out of 100,000, to ·13 % of the boys and to ·026 % of the girls. Giving the usual meaning to the term, Professor Pearson in the investi-

gation cited above found 10 % of the boys and 13 % of the girls to be dolichocephalic. Further, Table II shows clearly that there is no significant relationship between shape of head and intelligence, negative differences in mean and variability among the boys being accompanied by positive differences among the girls, the latter being possibly significant. Such small differences, however, can only be detected by making careful measurements of the crania; mere inspection of the heads of the children is obviously useless.

Almost equal importance is attached by Dr. Warner to defects of the palate. On p. 22 of his *Report* he says: 'Defect of the Palate, though less frequent than that of the cranium, stands next to it as having an almost equally high pathological co-relation.' He found that 2 % of the children had 'defects of palate'[1] which included 'Narrow', 'V-shaped', 'Arched or Vaulted', 'Cleft', and 'Other Defective Types'. Out of 796 boys and 525 girls with defective palates in the first part of the investigation, 324 boys and 232 girls are said to be 'mentally dull', or 40·7 % and 44·2 % respectively, as compared with 8·3 % and 6·3 % among the whole 50,000 children. We have thus a close relationship between defects of palate and mental dullness.

Now here again it is possible to compare Dr. Warner's results with those of another investigation in which, instead of relying on mere inspection, direct measurements were used. In 1905 Drs. Channing and Wissler published the results of a comparative examination of the hard palates of normal and feeble-minded individuals.[2] This investigation

[1] But all the children were not examined for defects of palate. See p. 28 below.

[2] Comparative Measurements of the Hard Palate in Normal and Feeble-Minded Individuals. A Preliminary Report. By Walter Channing, M.D.,

was undertaken 'because the assumption had been made that certain types of deformity are the correlates of feeble-mindedness. This assumption is so generally current that it is made a principle of diagnosis'.

The investigation was carried out in a most thorough manner. Instead of relying on a mere impression of 'defect' of palate, the authors took a cast of the palates of 1,010 inmates of schools for the feeble-minded and of 614 normal individuals, the technique of the casting process having been developed in dentistry. Every precaution was taken to ensure accuracy. A preliminary examination was made of the growth factor, and the methods of examination were standardized by repeated measurement of the same casts. Four measurements were discussed in their report. These were: (*a*) The minimum distance between the first molars, measured horizontally, from the bases of the molars; (*b*) the maximum height of the palate, measured from the approximate plane of the gum line; (*c*) the distance from the line connecting the two first molars to the alveolar point; (*d*) the distance between the canines, measured horizontally from their bases.

In Table III there is given a list of the means and standard deviations of these four measurements among the normal children and the feeble-minded for ages 6–13 [1] and over 20, together with the probable errors [2] of the differences. The maximum difference between these means is $1{\cdot}25 \pm {\cdot}14$ mm., while a large number of the differences are

and Clark Wissler, Ph.D. *American Journal of Insanity*, vol. lxi, no. 4, 1905, p. 687.

[1] In the extreme cases, I tested the effect of basing the means on a standard age distribution as shown in Eugenics Memoir VIII, p. 32, but found that the differences were not significant.

[2] The probable errors in Channing and Wissler's paper were calculated from the formula $\sigma/\sqrt{n}$ instead of from the usual $\cdot 67449\ \sigma/\sqrt{n}$. I have used the latter.

III. TABLE SHOWING THE MEANS AND VARIABILITIES OF MEASUREMENTS OF PALATES OF NORMAL AND FEEBLE-MINDED INDIVIDUALS.

Measurement.	Age.	Constant.	Males.			Females.		
			Normal.	Feeble-Minded.	Difference.	Normal.	Feeble-Minded.	Difference.
Width of Palate at 1st Molars	6–13	Mean	32·92	33·86	+·94±·19	32·81	32·25	−·56±·20
		S. D.	2·28	3·01	+·73±·13	2·35	2·63	+·28±·14
		No. of Observations	192	175		252	123	
	21+	Mean	34·75	33·77	−·98±·29	34·00	33·28	−·72±·29
		S. D.	3·35	3·61	+·26±·21	3·36	3·08	−·28±·21
		No. of Observations	126	125		49	115	
Height of Palate	6–13	Mean	12·14	13·39	1·25±·14	12·31	12·96	+·65±·16
		S. D.	1·75	2·28	+·53±·10	1·96	2·05	+·11±·11
		No. of Observations	188	174		250	123	
	21+	Mean	16·00	16·09	+·09±·22	...	14·87	...
		S. D.	2·31	2·63	+·32±·16	...	2·66	...
		No. of Observations	112	112			115	
Length of Palate	6–13	Mean	30·68	31·36	+·68±·21	30·70	30·59	−·11±·20
		S. D.	3·05	3·09	+·04±·21	2·34	2·65	+·31±·14
		No. of Observations	188	169		250	122	
	21+	Mean	28·37	29·50	1·13±·31	29·09	28·67	−·32±·25
		S. D.	2·39	4·27	1·88±·22	2·55	3·05	+·50±·18
		No. of Observations	104	112		48	102	
Width of Palate at Canines	6–13	Mean	23·57	23·53	−·04±·21	22·98	22·68	−·30±·18
		S. D.	2·31	3·01	+·70±·15	2·22	2·36	+·14±·13
		No. of Observations	187	177		261	127	
	21+	Mean	23·00	22·36	−·63±·21	22·14	21·77	−·47±·21
		S. D.	2·24	2·61	+·37±·15	1·65	2·89	+1·24±·15
		No. of Observations	112	124		50	115	

less than twice their probable errors, and in others a positive difference among the boys is associated with a negative difference among the girls.

In the same way we can compare the variability of those measurements among normal and feeble-minded individuals, and while the feeble-minded have generally the greater variability, the differences are small, the greatest being less than two millimetres. It is thus clear that the conclusions reached by the authors of this careful investigation must be accepted: 'that the absolute size of the palate seems to be the same for feeble-minded as for normal individuals, but that the variability of the feeble-minded is slightly greater than that of the normal.' The differences are so small, however, that they could not have been detected by any examination of the kind carried out by Dr. Warner.

We have now examined Dr. Warner's treatment of two characters capable of exact quantitative measurement, the size and shape of the head, and the form of the palate; it has been shown that the necessary measurements were *not* made, but that Dr. Warner depended on mere impressions instead, and further that the results obtained by him are wholly at variance with those obtained from other investigations in which such measurements were carefully made. What weight then can we give to his treatment of characters for which 'purely verbal classification' had to be employed, to his treatment of 'Nerve Signs', for instance, some of which he says 'entirely baffle description in anatomical terms'.[1]

Of these we can only deal here with one, the estimate made of the intelligence of the children. In the case of the L.C.C. investigation, Mr. Yule can hardly find words strong enough for his condemnation of this important part of the work. In amusing *crescendo* he objects to the categories under which the intelligence of the children was estimated by the teachers; he denies that the opinions of the teachers

[1] *Report*, p. 24.

on this point can be other than 'relatively as well as absolutely valueless', and finally suggests that the memoir will act 'as a warning that in future surveys, intelligence will be a very difficult character to deal with—if indeed it should be included at all'.

Now Mr. Yule has devoted an immense amount of time and trouble to the analysis of Dr. Warner's data, but nowhere has he a word of criticism for the estimates of intelligence used. Will it be believed that in Dr. Warner's investigation not only was the estimate of intelligence made by the school teachers,[1] but also that while in the L.C.C. investigation five categories of intelligence were used: 'brilliant', 'above the average', 'average', 'under the average', 'very dull and backward', in Dr. Warner's investigation the children were divided into two groups only, those 'under the average', and those not so classed?[2]

[1] Mr. Yule further assumes throughout his investigation that mental defect is only the extreme grade of poor intelligence, the possibility of its being a pathological entity is never even referred to. The world is no doubt a mad world, and it may be impossible in many cases to draw the line between eccentricity and madness; yet that many cases of insanity are pathological would be accepted by most investigators. Medical opinion at the present time is certainly in favour of some cases of mental defect being also pathological in character. We may be unable to define the limit at which normal stature and ateleiotic dwarfism meet, but few would be found to deny the pathological character of the latter. It is precisely so with mental defect and dullness. One of the points at present of essential importance is the discovery of an adequate definition of mental defect, which will suffice to differentiate two categories, the distinction of which is felt rather than formulated by both medical officer and teacher. The removal of this pathological element from our data should in itself have been sufficient to invalidate any comparison of the correlations founded on the L.C.C. records and Dr. Warner's data.

[2] This type of criticism of Galton Laboratory Memoirs is becoming increasingly frequent. All investigations of social problems are declared invalid unless they conform to certain laws laid down by the critics, and it might be supposed that these laws are to be applied to all investigations of the same problem, but that is not so; these laws are merely formulated for the purpose of ruling out of court any investigation with the results of which the critic does not happen to agree, and are quietly dropped when the results are, from the critic's point of view, satisfactory.

The necessity for a clear understanding of Dr. Warner's method of examination justifies the following rather long quotation from his *Report* (p. 10):

'Viewing a child, we see its body and some of the indications of brain action.

'The signs observed are of two kinds: (A) points of form, proportion and indications of type of development of the body and its separate parts; thus looking at the child, we note the cranium and the separate features, the ears, the nose, the palpebral fissures, and the mouth, i. e. its physiognomy; also its growth and the indications of nutrition.

'(B) Nerve signs are seen in the balance of the head, the spine, the upper extremity, and the digits as well as in the facial action and eye movements. These movements and balances of action or postures are observed as signs of the action and condition of the nerve centres. Inspection of the children is most conveniently conducted in a large and well-lighted room, the pupils being drawn up in ranks, a standard at a time, or in groups of about forty, so that the inspector may view each individual. It is convenient to fix the child's eyes by asking each in turn to look at an object held up, e. g. a shilling at the end of a pencil. The trained observer can read off the physiognomy of the individual features and their parts, the facial condition and eye movements, the balance of the head and body, &c., as quickly as a printed line.

'The children in the group are then requested to hold their hands out straight, the action being shown them momentarily; the balance is noted as a further indication of the nerve condition. Finally, the palate is inspected in every child.

'At each stage of inspection, children presenting deviations from the normal are asked to stand aside; any dull children

or special cases not picked out by inspection may now be presented by the teacher; the selected cases are kept and the other children are dismissed to the classroom.

'Each of the selected cases is then reviewed individually and described on a schedule form; the teachers' report concerning the child is taken down or filled in by them afterwards. Occasionally some detailed inquiry concerning a child may be made, or some brief mental examination may be desirable, but as a rule no questions are asked of the child.

'This method works smoothly and uniformly with a minimum of trouble to the teachers and pupils. The teachers almost universally acknowledged that the dull children had been selected by inspection, and very few were subsequently presented by them.'

This gives, however, so little information as to the classification of intelligence that the following additional quotations must be given:

'The teachers' report as to mental ability was added to the record of each child registered, and those stated to be below the average in ability for school work were registered as "Dull".' (*Report*, p. 13, and *Jour. R. Stat. Soc.*, 1896, p. 126.)

'The children reported by the teachers as mentally dull or below the average in ability for schoolwork were mostly selected by the signs observed before the teachers presented any who were passed over by the observer, and the teachers generally acknowledged that the dull children had been so selected.' (*Report*, p. 45.)

'The teachers give their report on the working power of each child noted in a fourth column. (*Jour. R. Stat. Soc.*, 1893, p. 72.)

'"Dull Cases" are "children reported by the teacher as

dull or below the average in school lessons".' (*Jour. R. Stat. Soc.*, 1893, p. 72.)

'The report of the teacher concerning each child was included. Mental dullness was observed or reported to us in 231 cases. It is probable that many more children were mentally dull; of those noted some attracted attention in other ways and some were presented to us by the teachers.'[1] (*Brit. Med. Jour.*, July 27, 1889, p. 187.)

Mr. Yule's version of Dr. Warner's procedure is rather different, and I quite fail to find any justification for his paraphrase of Dr. Warner's own words. He says:

'The return as to "dullness" is stated to have been based on the teacher's report, but this does not quite convey the actual procedure. Dr. Warner himself, I understand, picked out certain children to begin with, and these, subject to the teacher's confirmation, were entered as "dull" together with such other children as were then reported dull by the teacher (cf. *Report*, &c., p. 11). Dr. Warner's selections, his personal presence, and his explanations, would thus tend to secure a moderate degree, at least, of uniformity. Further, the investigation was voluntary[2] and unofficial . . .' (*Jour. R. Stat. Soc.*, 1910, p. 545.)

We see then that, except in the case of the 5,344 children

[1] This refers to the children dealt with in Dr. Warner's first interim report. It is to be noted that the term 'under the average' is not used here at all, although these children are included in the general report.

[2] The survey was a 'voluntary' one in the sense that permission had first of all to be obtained from the governing bodies of the schools concerned, but only in this sense. If Mr. Yule suggests that certain teachers 'volunteered' to carry out the classification of the intelligence of the children, as was the case in Prof. Pearson's school children investigations already quoted, he is going beyond the facts. When Dr. Warner had obtained permission to examine a school every standard in that school was examined ('all the children are seen in the three departments of the school, infants, boys, and girls'. *B.A. Reports*, 1893, p. 614), and so far as the individual teachers were concerned, they had apparently no choice in the matter.

examined in Jan. 1889, Dr. Warner is careful to lay on the teachers the whole responsibility for the classification of intelligence.

And what are the results of this classification? If, as we have reason to believe, the distribution of intelligence is nearly normal, we should expect that 50% of the children would be classed as 'under the average'. This percentage would of course be considerably reduced by the use of an 'average' group, but no such group was used by Dr. Warner, yet in his investigation, only 7·4% of the children are classed as under the average. It should be noted also that this includes the 1% of children who are now classed as 'mentally defective' and are trained in 'special' schools. What is the explanation of this extraordinarily small percentage of 'under the average' children? It is, I am convinced, to be found in Dr. Warner's method of examination.

We have seen that a certain number of children were selected by Dr. Warner as possessing some visible defect. These amounted to 18% of the whole. In addition 'dull children or children not picked out by inspection' were presented by the teacher, but Dr. Warner states that very few were so presented; he does not, however, give the actual numbers. For each of those selected cases the schedule already described was filled in, those children being re-examined for this purpose, and the teachers were then asked to say which of the selected cases were 'under the average in ability for school work. The extraordinary method of procedure by which the 82% of children who are said to be normal in every respect are summarily dismissed, and detailed examination is reserved for the remaining 18%, demands further notice. Dr. Warner's own words make it quite clear that all the children were not examined in the same way, and it seems certain that the very high correlation

found between every pair of defects is due to his method of examination.

Strong evidence for this view of the matter is to be found in Dr. Warner's description of his examination of the palates of the children. On p. 11 of his *Report* he says that 'the palate is inspected in every child', but this is very far from being the case. In Table XI, p. 98 of his *Report*, the occurrence of Binary and Triple Defects is discussed, not among the whole of the 100,000 children but only among 5,344 children who formed the material for Dr. Warner's first interim report.[1] Now of these 5,344 children, the records of whose examination were selected for specially detailed analysis, only 459 were examined for defects of the palate. I have already shown that the method of examination of the 82 % of children who are said to be normal in every respect was extremely cursory, but we see here that not even all of the 'scheduled' children were examined for all the characters tabulated. Yet this sample of children is actually selected for a discussion of the occurrence of binary defects, of defects of cranium and palate together, &c.! Tables XI, XII, and XVIII of his *Report* are of course valueless and actually misleading.

But that is not the only objection to the examination of the palate. Among those 5,344 children whom Dr. Warner first examined there were 51 deaf and dumb children, *and the palates of these children were examined in every case.* Head measurements of these children and particulars of their general health were also obtained, and inquiries made as to the occurrence of cousin marriages. This furnishes the real explanation of Mr. Yule's extraordinarily high coefficients of association between pairs of defects. A child

[1] Dr. Warner says 'The number of children presenting binary defects has not been determined'. (*Report*, p. 28.)

who presented any easily noticeable defect was carefully examined for the presence of other defects, while those who presented none of the more prominent defects were passed over without further examination. These considerations naturally lead us to ask what is the association between mental capacity and the state of nutrition, the test case selected by Mr. Yule, among those children who were more carefully examined? Now Mr. Yule, in his original discussion of Dr. Warner's data, has given the Coefficients of Association between Mental Dullness and Low Nutrition in cases where the children have either developmental defects or nerve defects or both. These Coefficients of Association, however, give too high values, and therefore I have given in Table IV the Correlation Coefficients between Mental Dullness and Low Nutrition in cases where other defects are present.

TABLE IV. THE CORRELATION BETWEEN MENTAL DULLNESS AND LOW NUTRITION AMONG CHILDREN SUFFERING FROM OTHER DEFECTS.

Defect present in children.	Correlation Coefficients.	
	Boys.	Girls.
Developmental Defect but not Nerve Defect	$+\cdot11 \pm \cdot02$	$-\cdot01 \pm \cdot02$
Nerve Defect but not Developmental Defect	$+\cdot05 \pm \cdot02$	$+\cdot00 \pm \cdot02$
Developmental and Nerve Defect	$+\cdot14 \pm \cdot02$	$-\cdot00 \pm \cdot03$

The actual values given above are all small, however; they are in fact of the same order as the correlation coefficients given in the Galton Memoir. We see then that *so far as the children for whom schedules were filled up are concerned*, the only children on whom any real examination was made, Dr. Warner's material shows hardly any relationship

between mental capacity and the state of nutrition. This is precisely the result obtained in the Galton Memoir.

A further point deserves consideration. In addition to 'mental dullness' three classes of defects are considered, developmental defects, nerve signs, and bad nutrition. The association of these classes of defects with 'mental dullness' is nearly the same. Thus, in cases of developmental defects, 38·3 % of the boys and 41·5 % of the girls are 'mentally dull'; in cases with 'nerve signs', 40·1 % of the boys and 42·4 % of the girls are 'mentally dull', while in cases of 'low nutrition' the percentages are 39·0 and 40·6 respectively. If we now classify children as having no defect, one, two, or three classes of defects, we can find the percentage of mentally dull in each class. These results are given in Table V.

V. TABLE SHOWING THE PERCENTAGE OF CHILDREN WHO ARE 'MENTALLY DULL' AMONG CHILDREN WHO HAVE 0, 1, 2, OR 3 CLASSES OF DEFECTS.

		1888 Investigation. Percentage of 'mentally dull'.		1892 Investigation. Percentage of 'mentally dull'.	
		Boys.	Girls.	Boys.	Girls.
Number of Classes of Defect.	3	46·6	41·2	53·7	50·6
	2	38·6	42·0	43·1	45·8
	1	36·6	41·6	37·1	39·3
	0	1·1	0·6	1·5	1·4

We see from this that the 'piling up of defects' makes comparatively little difference in the percentage of children who are 'mentally dull', and among the girls of the 1888 investigation, no difference at all. Again, if we take cases with low nutrition, but neither with developmental defects nor nerve signs, the percentages who are mentally dull are 54·1 (boys) and 66·7 (girls) for the 1888 investigation, and

36·8 (boys) and 32·5 (girls) for the 1892 investigation; among cases with all three defects the percentages are, as we have just seen, 46·6 (boys), 41·2 (girls), and 53·7 (boys), 50·6 (girls).

The same results appear when we deal with the effects of binary defects of development, details of which are only given for the 1888 part of the survey. Among children with neither developmental nor nerve defects, the percentages of 'mentally dull' were 1·1 for the boys and 0·6 for the girls. Among those who had cranial defects only, the percentages were 36·4 and 47·9; among children, however, who suffered from some other defect of development in addition to defect of cranium, 46·5 % of the boys and 42·8 % of the girls are 'mentally dull'! These results might be multiplied indefinitely but what do they suggest? We saw that instead of an expected 50 % who are classed as 'under the average in ability for school work', only 7·4 % were so classed, while among the children for whom schedules were filled up, 40·8 % are said to be 'under the average', a reasonable approach to the theoretical 50 %. We saw that among those 'scheduled' children there was on the whole no association between pairs of defects, and that in some cases the association was a negative one. It has been shown that the piling up of defects increased the percentage of 'mentally dull' in some cases, and in others decreased this percentage. Finally, note the manner in which the examination was practically confined to 18 % of the children while the other 82 % were summarily dismissed as 'normal'.

All these point to only one conclusion—that the teachers have given quite fairly their estimate of the intelligence of the 18 % of children for whom schedules were filled up, but have had no opportunity of doing so for the other 82 % who

are said to have been 'normal'. This, I am convinced, is the only satisfactory explanation of Dr. Warner's results.

There are many other points in Dr. Warner's data which are open to serious criticism, but I shall content myself with drawing attention to the want of agreement between the results of the 1888 and 1892 parts of the survey and with agreeing with Mr. Yule in protesting against the extraordinary number of slips in the numbers given.

The Galton Memoir on the influence of environment on the intelligence of school children was condemned by Mr. Yule on the grounds that (*a*) the teachers' estimates of the intelligence of the children were worthless, and (*b*) that the results were altogether at variance with those Dr. Warner and Mr. Yule obtained from the survey of the former, in which also the teachers were responsible for the estimates of intelligence.

I have shown that the judgement of teachers in elementary schools on the intelligence of the school children, when tested against place in class (of which Mr. Yule approves), turns out in three lengthy investigations to be of decided value.

Mr. Yule's citation of Dr. Warner's results has rendered necessary a detailed criticism of that survey, and it has been shown that the methods of examination were such that the results cannot be accepted as of any value.

I should have wished to be spared this criticism of work, which, however inadequate in method and erroneous in conclusion, served the useful purpose of drawing attention to mentally defective children. I would willingly have allowed Mr. Yule's own treatment of these papers to pass unnoticed. Mr. Yule says that I have not referred to these 'much more extensive surveys'. The want of reference explains itself, for these surveys were not only conducted in an unscientific manner, but had been treated statistically by

a method which has not commended itself to statisticians, and which grossly exaggerated even the results which flow from such defective data.[1] The staff of the Eugenics Laboratory never goes out of its way to attack other people's work; it states its own conclusions and the evidence on which they are based, but it feels bound occasionally to reply to innumerable critics, who, if they have done any work at all, in nine cases out of ten have done it on a still more 'dubious foundation' to which they have never even applied their own canons of criticism.

Mr. Yule has repeated in this case precisely the type of criticism he made once before in attacking qualitative categories. He has asked why other things had not been done; which either could not be done or had been done. In this particular case, place in class or examination was not available—we knew it, however, to be very highly correlated with the category actually used. It is reasonable to suppose that Mr. Yule was unaware of this correlation, but this does not justify him in sweeping condemnation of the Eugenics Laboratory and its investigations, investigations which are often based on the general drift of work in progress fully known to the members of the staff, but not yet ripe for publication.

The memoir on the *Influence of Defective Physique and Unfavourable Home Environment on the Intelligence of School Children* was issued, as it states in its opening words, with two very definite purposes: '(*a*) to illustrate the difficulties which arise in attempting to make reliable and comparable observations on school children, and (*b*) to indicate the difficulties met with in the statistical treatment

[1] The associations found by Mr. Yule from the census returns for 'blindness', imbecility, and deaf-mutism are equally fallacious, or rather more so. Thus the association of deaf-mutism and mental defect for the census of 1901 gave by Mr. Yule's process .82, while by fourfold correlation process it is .27!

of such observations, if they are not made with due regard to the needs of the statistician.' To carry out these purposes, it was necessary to emphasize every point where there was defect in the data discussed. And these purposes have been fulfilled, as the many inquiries made by school medical officers to the Laboratory as a result of the memoir demonstrate. That Mr. Yule should find my emphasis of defect in the data sufficient to discredit the memoir only indicates how little he understood its purposes—he could hardly have read its opening paragraph.

But beyond and apart from these defects in the data, upon which I purposely laid stress, Mr. Yule's criticisms have wholly failed to convince me that there exists any environmental condition producing an effect on the mentality of the child comparable with that of heredity. Mr. Yule cites Dr. Warner's result, that poor mentality arises from ill-nutrition—nearly all modern medical experience shows it to be essentially a congenital character, not the product of ill-nutrition. I cannot accept, in view of what I know to the contrary, Mr. Yule's sweeping condemnations of the untrustworthiness of the teacher's judgement, and I think it far more probable that my low correlations of environment and intelligence are due to the fact that the intelligence is not a product—except indirectly through the heredity factor—of environment, than to the hypothesis that the teachers' judgements were 'of no value for any serious purpose'.[1] Those who assert that intelligence is a product of nutrition should certainly set to work and produce more reliable data than those of Dr. Warner, and apply to them more satisfactory statistical methods than those adopted by Mr. Yule.

[1] Yule, *School Hygiene*, vol. i, p. 475.

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